On Range-Momentum Measurements for Electrons in Gases*

G. F. O'Neill† and W. T. Scott‡
Brookhaven National Laboratory, Upton, Long Island, New York
September 5, 1950

THE high pressure cloud chamber offers a convenient means for determining the range-momentum relations for slow electrons in gases. The purpose of this note is to report on some preliminary measurements made with a high pressure cloud chamber described previously.[1] Gamma-rays from Na^{24} produced Compton electrons of momenta up to 1.1 Mev/c, which were investigated in hydrogen and helium at 136 atmospheres pressure and with a regionally calibrated magnetic field of approximately 4000 gauss. The vapor was a water-alcohol mixture.

Because of the high energy loss in the dense gases, the particles were bent into spirals (Fig. 1) instead of the circles found at low pressure. Thus, each track that can be seen to its end could be used to give a range-momentum relation. A good fraction of the statistical fluctuation was eliminated by excluding trucks having high energy knock-ons, with accompanying sudden curvature changes. To obviate the necessity for corrections for drift in the line of sight, only regular spirals nearly in the plane of the cloud chamber were chosen. The curvatures were measured by fitting circles at approximately 1-cm intervals along the path. The results of measurements on four tracks in helium and three in hydrogen are given by the points in Figs. 2 and 3. The large amount of useful data available from each track is evident.

An analysis of scattering induced curvature in high pressure gases will be given in a later paper. It has been found that with the 4000-gauss magnetic field about 1/10 of the curvature was due to scattering. In a heavier gas, such as argon, the scattering curvature is about equal to the magnetic curvature. A stronger magnetic field (such as that in the high pressure chamber with a 36,000-gauss magnetic field nearing completion at the Brookhaven Laboratory) would be necessary to use this method of obtaining the range-momentum relation in argon at this pressure, and, of course, a high range of energies would have to be used.

FIG. 1. Electron spirals in helium, showing one useful track (actual diameter 3 cm) and several others.

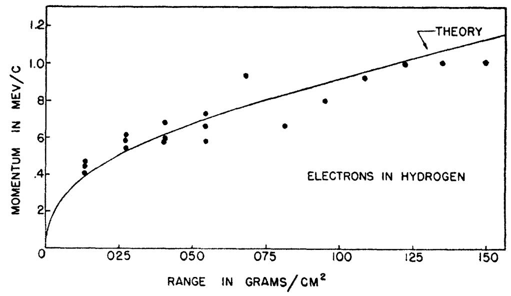

FIG. 2. Experimental and theoretical range-momentum relation for electrons in helium.

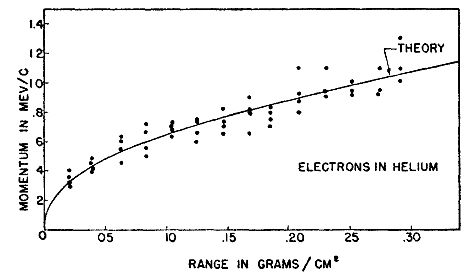

FIG. 3. Experimental and theoretical range-momentum relation for electrons in hydrogen.

It is of interest to compare these experimental points with the usual energy loss theory. Radiation loss can be neglected, as the only cases of importance would be the relatively rare emission of a large fraction of the energy in one photon, resulting in a detectable sudden change of curvature. No tracks with such curvature changes were included.

The collision loss was calculated from Eq. (76) of Møller,[2] with use of Rossi and Greisen's formula[3] for small energy losses. The value of the ionization potential $I(Z)$ was taken from experiments of Mano[4] on alpha-particle ranges. A knock-on electron was considered as being certainly visible if its energy was 64 kev $= mc^2/8$, and this value was used as an upper limit in the integration of Moller's formula. Numerical integration was used above 375 kev/c momentum loss; below this value a curve of the form $pc = AR^{0.43}$ was used,[5] using the ordinate and slope of the integrated curve at $pc = 375$ kev to determine R at this point, and then finding A.

The resulting curves are given in Figs. 2 and 3. It is evident that even a few tracks give a reasonable confirmation of the theory, and that this method is capable of yielding rather accurate results.

We wish to acknowledge the advice and assistance of A. R. Hoke, W. A. Tuttle, and R. P. Shutt in connection with the operation of the cloud chamber at Brookhaven.

* Research carried out at Brookhaven National Laboratory, under the auspices of the AEC.
† Now at Fordham University. The experimental work here reported was performed by the first-named author at Brookhaven National Laboratory as part of a Ph.D. thesis at Fordham University.
‡ On summer leave from Smith College, Northampton, Massachusetts.

1 Johnson, Benedetti, and Shutt, Rev. Sci. Inst. 14, 265 (1943).
2 C. Møller, Ann. d. Physik 14, 531 (1934).
3 B. Rossi and K. Greisen, Rev. Mod. Phys. 13, 240 (1941).
4 G. Mano, Ann. de Physique 1, 407 (1934).
5 This formula was derived by fitting a power-law expression to curves in D. J. X. Montgomery, *Cosmic-Ray Physics* (Princeton University Press, Princeton, 1949).

FIG. 1. Electron spirals in helium, showing one useful track (actual diameter 3 cm) and several others.